ANTA 401 Literature Review

The inadvertent introduction of non-native species to Antarctica

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Abstract

The author reviews current themes in the literature dealing with the inadvertent introduction of non-native species to Antarctica The topic is introduced, the terminology used is scrutinised and the reasons for considering non-native species objectionable are analysed. The impact of climate change and the Antarctic's unique system of governance is examined. The author's conclusions revolve around the many paradoxes that human interaction with Antarctica necessarily entails and the compromises that must inevitably be made.

Introduction

The inadvertent introduction of non-native species into Antarctica is a subject of intense current interest, debate and research. Five non-native species have already been identified in Antarctica (Convey 2008) and a number of research projects, proposals and strategies are being developed to investigate the issue further and to mitigate its possible effects. Delegates at the 2006 Antarctic Treaty Consultative Meeting (ATCM) agreed that "the issue of non-native species should be given the highest priority" (Edwards 2006). The International Polar Year *Aliens in Antarctica* project was launched in 2007 by the Scientific Committee on Antarctic Research (SCAR) to “help inform the Antarctic Treaty parties of the size and nature of the threat and possible mitigation methods.” (ATCM 2007). A major new review of all systems and procedures was published as recently as August 2010 (Hughes and Convey 2010); Antarctica New Zealand is currently offering its own research scholarships on just this subject. The literature, in both the academic and popular publications, is vast and growing. It focuses on the principles of measuring and preventing non-native species in general rather than on the impact or possible remediation measures of the particular species already inadvertently introduced

This review will examine a range of published sources on the inadvertent introduction of non-native species to Antarctica and attempt to identify the topic’s recurring questions and characteristics. It will exclude the many hundreds of inadvertent and deliberate introductions of non-native species to sub-Antarctic Islands.

Definitions

The vocabulary surrounding this issue is itself contentious: a standard scientific dictionary definition of the word *native* appears to be straightforward enough (Allaby 2010), and the Environment Protocol uses the word native as the axiomatic centrepoint on which its other definitions depend, (Environment Protocol 1991). However the word *native*, and even more so its various antonyms (*non-native*, *exotic*, *introduced*, *invasive*...) are charged with additional ecological, political, social and economic meanings such that their unambiguous use requires considerable caution. Not all the readings I have examined provide clear definitions of the terminology they are using.

An exception is the exhaustive overview of the subject in *Biological Reviews* (Frenot et al. 2005) which proposes four categories of non-native species:

- Alien: introduced to an ecosystem as a result of human activity (including species that arrive by natural means to a specific ecosystem but are alien to that bio-geographical zone)
- Transient alien : survived in small populations for a short time period but either died out naturally or was removed by human intervention
- Persistent alien : survived, established and reproduced for many years in a restricted locality, but has not expanded range from that location
- Invasive alien : spread into native communities and displaced native species

No fewer than six categories of nativeness have been proposed for use in developing bio-diversity policy in Great Britain (Usher 2000), namely:

- native
- formerly native
- locally non-native
- long-established
- recently arrived
- non-native

Charles Warren suggests that the terms native and alien are inherently unhelpful and proposes their replacement with terminology based purely on the type and amount of damage a particular species inflicts, rather than classifying it according to its original location at a particular time (Warren 2007). This time may be chosen arbitrarily or it may be chosen with care in order to include, or indeed exclude, a particular species from a particular categorization. The categorization then inevitably rests on social, political or economic factors, rather than purely biological or ecological ones.

Finally social scientists find the terms *native* and *alien*, with their xenophobic aftertaste, at the very least awkward to accommodate, at worst downright offensive (Wong 2005).

Some of the non-native species inadvertently transferred to Antarctica have themselves been non-natives in the areas from which they had come. For example several of the species transported from the Falkland Islands and South Georgia to the British Antarctic Survey

station at Rothera in 2005 (Hughes et al. 2009) were by no definition native to those places. Whether the locations that a species had already successfully colonised, whether the timing and other circumstances of this earlier colonisation was important, and whether in turn tracing these colonisations back to even earlier colonisations should be of any particular extra concern was not stated in this article.

Notwithstanding these definitional difficulties this review will persevere with the terms *native* and *non-native*.

What is so bad about non-native species?

The readings covered for this review regularly assume that any and all non-native species introduction is undesirable, though it is not difficult to find individual examples where this is not so (Gozlan 2009, FAO 2005, Tablado et al. 2010). These counter-arguments are advanced for economic reasons where plants and animals farmed, harvested or otherwise managed for profit are plainly important to the communities where this occurs. For example over half of New Zealand's exports by value are produced directly from the intensive management of species that are not native to the country (Easton 2009).

The Environment Protocol's unequivocal statement in Annex 4, Article 2, that *No species of animal or plant not native to the Antarctic Treaty area shall be introduced onto land or ice shelves or into water in the Antarctic Treaty area except in accordance with a permit* pre-supposes, or at least has been taken to mean, that there can be no beneficial introductions and that Antarctica's low biodiversity is so vulnerable as to require complete biological isolation. In view of the number of human visitors to Antarctica, it is debatable whether this policy of

complete containment is feasible, and this is discussed below, but many writers identify the simple impossibility of predicting the effect of an introduction as sufficient *de facto* justification for the policy. For example, in describing the variety of consequences of an undesirable introduction, Dana Bergstrom states: "...the impact of alien species could range from a minor, transient introduction, to a substantial loss of local biodiversity and changes to ecosystem processes and evolution" (Butterworth 2008). Here, even while allowing for minor and transitory introductions that would presumably do little or no harm, the author identifies the possible catastrophic effects at the other end of an impact scale.

Antarctica's long isolation from neighbouring land masses makes its native species, few though they may be, particularly vulnerable to the effects of introductions. (De Poorter 1998). The particular vulnerability of islands, and in this context Antarctica may be so regarded, is also well documented (Paulay 1994 Simberloff 1995, Simberloff 2000). Separate sites within Antarctica which are isolated from each other can also be satisfactorily regarded as ecological islands (Hughes and Convey 2010).

Non-native introductions are not therefore necessarily essentially malign. Indeed some may, depending on the assessment criteria used, even be beneficial. However given the catalogue of catastrophic introductions elsewhere in the world, especially on islands, the irreversibility of introductions, and the particular risk factors presented by Antarctica's isolation, the Environment Protocol's ambitious aim of admitting no new species at all does not seem unreasonable. Monitoring or enforcing the policy may be difficult but at least it is simple - monitoring and enforcing a more complicated system of partially permitted introductions would be even harder. It should be noted that the permit arrangements mentioned in the Environment Protocol were intended to relate to the deliberate introduction of specimen species in the laboratory. I deduce from the readings covered in this review that it is inconceivable that a non-native introduction into the wild would ever be permitted.

Data gathering

The pressing need to gather accurate, up to date information about non-native species introductions, how they reach Antarctica, their likely viability when there and the risk they pose is a recurring characteristic in the literature under review. As Professor David Walton of the British Antarctic Survey states: *Whatever we do, we should make it a proportionate response and one based on knowledge* (Walton 2006). The most comprehensive article identified for this review (Hughes and Convey 2010) makes frequent mention of the lack of data across species and geographical regions and the way that this stops policy making in its tracks for want of information. The IPY *Aliens in Antarctica* project was an attempt to remedy this. It used the four barrier invasion model (Hughes et al. 2009). According to this model a species must overcome a sequence of four barriers, in order to colonise a new location. It must first reach the new location, it must then establish itself there, it must then spread and finally it must transform the local ecology to its own advantage. These are identified as the transport barrier, the establishment barrier, the invasion barrier and the transformer barrier. The *Aliens in Antarctica* programme addressed only the first, arguing that the others do not arise until the first is breached (ATCM 2007).

The questions the project posed, in other words the information it was seeking to gather, were:

1) What is the propagule load being carried by the various transport components? Are some pathways carrying more propagules than others?

2) What is the propagule composition (number of species) being carried by the various transport components?

3) Are some categories of traveller more likely to be carrying propagules than others?

4) Are some pieces of gear more likely to be carrying propagules than others?

5) How viable are the propagules in Antarctic conditions?

A detailed study of a particularly heavily used route to Antarctica, from Christchurch to the Ross Sea area, has been carried out and identifies a number of risk factors that arise from the intensive shipment of food, machinery, equipment and personnel (Fortune 2006). Lack of data is again mentioned as a challenge and it is the author's intention to provide baseline data for future researchers.

It is of course possible that non-native species could reach Antarctica naturally, (Hughes et al, 2009) and it is also possible that hitherto unknown or undescribed species could already be there, having survived previous glaciations (Convey 2007). Both naturally occurring establishments of non-native species and the discovery and identification of existing native species, are beyond the scope of this review.

A large volume of new information was collected as a result of the contravention of the Environmental Protocol which occurred in December 2005 when construction vehicles were transported from the Falklands Islands and South Georgia to the British Antarctic Survey's Rothera station. The vehicles were contaminated with more than 132 kg of soil. This event is described in the article in *Biological invasions* already cited (Hughes et al. 2009).

The soil on the construction vehicles was retained and subjected to a detailed examination and laboratory analysis and this forms the bulk of the article. Specimens of two species of grass and two of moss were found intact within the mud. A further seven vascular plants were cultured and identified. Sixteen invertebrate animal species were also found, including spiders, midges and worms. Bacteria, fungi, 38 individual nematodes and rotifers, and 40,000 seeds, completed the findings.

Although many of these sub-Antarctic species would not survive in Antarctica, the authors argue that the scale of this contamination made it an event that posed a significant risk. The fact that such a large volume of material was available for analysis, while in itself potentially disastrous, was in fact of considerable analytical value. The incident led to the British Antarctic Survey writing new guidelines on vehicle movements which were presented as a working paper at the 2009 meeting of the Committee for Environmental protection (United Kingdom 2009). It is an indication of how patchy data was at the time this article was published (July 2009) that while the number of tourist visitors was accurately known (33,054), the number of scientists was not. The figure of *about 5000* scientific visitors is given and no comment is made, nor elaboration provided, on the remarkable difference in accuracy.

A report on the *Aliens in Antarctica* project was presented in August 2010 which outlines the project's achievements (COMNAP/SCAR 2010). These include the creation of the Alien Species Checklist, a database at the Australian Antarctic Data Centre, part of the Australian Antarctic Division.

Disease

The introduction of disease is beyond the scope of this review, though it remains a matter of major concern and too little information (Frenot et al. 2005). Birds have been identified carrying antibodies to various diseases, but as they can range very widely, a direct link between disease in the wildlife of Antarctica and human activity is not apparent.

Climate change

Antarctica’s low bio-diversity and its ability to resist invasion is, of course, due in no small part to its severe climate. Accidental introductions usually have little chance of survival. (Fortune 2006, Hughes and Convey 2010) However the warming recorded, especially in the Antarctic Peninsula, is highlighted in the literature reviewed as an important further reason for developing programmes to minimise introductions.

Dana Bergstrom of the Australian Antarctic Division states: “With increases in temperature occurring in some parts of Antarctica, greater numbers of alien introductions and more successful invasions by aliens are likely, with consequent increases in impacts on ecosystems” (Butterworth 2008). The same point is widely made (Hughes and Convey 2010, Frenot et al. 2005).

Non-native introductions are inherently undesirable, and a higher temperatures increases both their likelihood of reaching Antarctica and their likelihood of thriving when there.

The rules and sanctions

Antarctica’s peculiar governance system presents a unique set of challenges in dealing with non-native introductions (Bargagli 2005, Hughes and Convey 2010). These writers consider the lack of a single source of sovereignty, the Antarctic Treaty's working model of co-operation and consensus, the way the Antarctic Treaty System is funded, and its multi-national composition as factors which retard rather than accelerate policy development, let alone policy implementation. Furthermore, Antarctic policy is just one strand in a complicated tangle of policy issues that exists between each pair of Antarctic Treaty

members, with political, trade and economic considerations inevitably taking priority. It is therefore no surprise that agreement by consensus is a slow and convoluted process. The absence of an executive branch to the Antarctic 'government' means that implementation and monitoring of agreed policies is entirely dependent on the goodwill of the parties involved: national research programmes, tourism operators and private individuals.

Article VII of the Antarctic Treaty and Article 14 of the Environment Protocol cover the right of inspection, the original purpose of which was to ensure no military activities were being pursued. The plain practical difficulties of inspecting remote and isolated scientific research sites is however obvious.

Conclusion – paradoxes

The situation that prevails in 2010 is one of paradox. For hundreds of years, human activity involving trade and travel has inadvertently moved countless biological species from one location to another. Food production and wealth have increased, but individual species have suffered calamitously. The *homogocene* has been jocularly coined to describe this phenomenon. The balance between on the one hand preserving the biological integrity of Antarctica and on the other hand restraining those human activities that jeopardise it, is exquisitely poised and one that politicians will find very hard to strike.

Tourists and scientists, between whom the Environment Protocol makes no distinction in its prohibition on the introduction of non-native species, both risk contaminating the subject matter which motivates both categories of visitor to come to Antarctica in the first place. Scientists benefit from a pristine environment and its use as a supremely clean laboratory, yet their very presence risks reducing its cleanliness and thus its scientific value. Similarly

tourists seeking a wilderness environment untouched by human intervention reduce, by their visit, these very qualities and thus the value of the experience.

The *Aliens in Antarctica* project found that the commonest vector for unintended dispersal of propagules was field scientists and tourist support personnel. The Christchurch-Ross Sea study found numerous propagules being regularly transported to Antarctica to support scientific activity at the New Zealand, American and Italian bases in the Ross Sea area (Fortune 2006). While both the International Association of Antarctic Tour Operators (IIATO) and national programmes operate under defined guidelines, it is worth noting that two particularly egregious infringements of the system were by scientists: at the British station at Rothera (Hughes et al. 2009) and the Polish station at Arctowski (Osyczka 2010). The five proven introductions are all in the vicinity of scientific research stations (Hughes and Convey 2010). I infer that a greater proportion of tourists are aware of the rare value and high ecological risk attached to their visit and therefore behave responsibly and in accordance with guidelines. I would also infer that the trip of a lifetime for a tourist contrasts very starkly with a trip done many times by field scientists and tourist support personnel, for whom rigorous protocols that prescribe movements, methods and cleaning procedures become more vexatious, and therefore less likely to be followed, with each visit. There is a ray of hope then, since these higher risk visitor categories are smaller in number than tourists and are not beyond the reach of an imaginative environmental education programme, regularly refreshed and re-inforced.

None of the literature that I have reviewed engages the quintessential issue that the most invasive species of all, *Homo sapiens*, by definition the vector of every inadvertent non-native introduction, should not be in Antarctica at all. The Treaty system's active encouragement of extensive scientific research and its simultaneous prohibition on the introduction of non-native species is to this extent the most profound paradox of all. The

rational solution would be to deny our own nature, forego new knowledge and stay away. A more likely prognosis is continuous improvements to risk assessment, better voluntary guidelines, and sophisticated awareness programmes; and an implicit acceptance that new scientific knowledge comes at a significant, but ultimately acceptable, environmental risk.

Bibliography

Allaby, M. (2010). A Dictionary of Ecology. 4th ed. Oxford: Oxford University Press.

ATCM (2007) IPY Aliens in Antarctica, information paper 49. Delhi: XXXth Antarctic Treaty Consultative Meeting.

Bargagli, R. (2005). Antarctic Ecosystems: Environmental Contamination, Climate Change and Human Impact. Berlin: Springer.

Butterworth, J. (2008). On guard against an alien invasion. Australian Antarctic magazine (14), 28.

COMNAP/SCAR (2010). Report of Non Native Species workshop, held Buenos Aires, 8 August 2010.

Convey, P. (2008). Antarctic Biodiversity. Science 317 (5846), 1877-1878.

De Poorter, M. (1998). Introduction of non-native species in the Antarctic treaty area: an increasing problem. Information Paper presented to the XXII ATCM Tromso, Norway, May 1998.

Easton, B (2009). Economy - External trade, Te Ara - the Encyclopedia of New Zealand, updated 3 March 2009 [Viewed 19 November 2010]. http://www.teara.govt.nz/en/economy/6

Edwards, R. (2006). Alien species at the gates of Antarctica. New Scientist, 191 (2558)

FAO (2005). Fisheries and Aquaculture topics. Introduction of species. Topics Fact Sheets. Text by Devin Bartley. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 27 May 2005. [Viewed 19 November 2010]. http://www.fao.org/fishery/topic/13532/en

Fortune, A L. (2006). Biosecurity at the Extreme: Pathways and Vectors Between New Zealand and Scott Base, Antarctica. Christchurch: University of Canterbury, unpublished Master of Forestry thesis.

Frenot, Y., et al. (2005), Biological invasions in the Antarctic: extent, impacts and implications, Biological Reviews (80) 45-72.

Gozlan, R. E. (2009). Introduction of non-native freshwater fish: is it all bad? Fish and Fisheries 8(9), 106-115.

Hughes, K.A., et al. (2009). Accidental transfer of non-native soil organisms into Antarctica on construction vehicles. Biological invasions 12 (4), 875-891.

Hughes K. A. and Convey P. (2010). The protection of Antarctic terrestrial ecosystems from inter- and intra-continental transfer of non-indigenous species by human activities: a review of current systems and practices Global Environmental Change 20 (2010) 96–112.

Osyczka, P. (2010). Alien lichens unintentionally transported to the “Arctowski” station Polar Biology 33(8), 1067-1073.

Paulay, G. (1994). Biodiversity on Oceanic Islands: Its Origin and Extinction. American Zoologist 34 (1), 134-144.

Protocol on Environmental Protection to the Antarctic Treaty (1991).

Simberloff D. (1995). Why do introduced species appear to devastate islands more than mainland areas? Pacific Science 49(1), 87-97.

Simberloff, D. (2000). Extinction-proneness of island species - Causes and management implications. Raffles Bulletin of Zoology, 48 (1), 1-9.

Tablado, Z., et al. (2010). The paradox of the long-term positive effects of a North American Crayfish on an European community of predators. Conservation Biology, 24 (5), 1230-1238.

United Kingdom (2009). Procedures for vehicle cleaning to prevent transfer of non-native species into and around Antarctica. Working Paper 32. Committee for Environmental Protection XII, Antarctic Treaty Consultative Meeting XXXII, Baltimore, USA, 6–17 April 2009.

Usher, M. B. (2000).The nativeness and non-nativeness of species. Watsonia 23: 323-326.

Walton, D. (2006). Antarctic biosecurity – making it happen. Antarctic Science 18(2), 161.

Warren, Charles R. (2007). Perspectives on the ‘alien’ versus ‘native’ species debate: a critique of concepts, language and practice. Progress in Human Geography 31(4), 427–446

Wong, J.L. (2005). The ‘native’ and ‘alien’ issue in relation to ethnic minorities. ECOS 26 (3/4), 22–27.